Equisetum X litorale in Illinois, Iowa, Minnesota, and Wisconsin

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The cross between *Equisetum arvense* L. (Field Horsetail) and *E. fluviatile* L. (Water Horsetail) results in the hybrid *E.* × *litorale* Kuhl. (Shore Horsetail). It is distinguished from its parents by its abortive spores and intermediate anatomical and morphological traits (Hauke, 1978). The hybrid occurs less frequently in the Midwest than hybrids between unbranched species of *Equisetum*. The hybrid was reported from one county in Illinois (Mohlenbrock & Ladd, 1978) and four counties in Wisconsin (Hauke, 1965). It was not reported from Iowa (Peck, 1976) nor from Minnesota (Tryon, 1954), even though both parents occur together in those states. Its recent discovery in Minnesota (Peck & Swanson, 1978) initiated a field and herbarium search that uncovered a second locality in Illinois, first and second localities in Iowa, second, third, and fourth localities in Minnesota, and eight new localities in Wisconsin. Most of these new localities are on or adjacent to the flood-plain of the Mississippi River or its tributaries. The 2–3 ha stand located in Allamakee County, Iowa, is probably the largest stand of the hybrid in North America (pers. comm. with Drs. Hauke and Wagner). Consquently, efforts were made to study the habitat, stand dynamics, and reproductive biology of the hybrid at this locality to identify factors which clarify the origin, abundance, and persistence of the hybrid in this locality. Observations also were made at 16 of the 20 localities of the hybrid in these four states, but in less detail.

A summary of locality data is provided by *Fig. 1* and by citations from herbarium vouchers (new county records indicated by *). The original Illinois locality (Lee County) is accepted from the report by Mohlenbrock & Ladd (1978); voucher citation was not given and the specimen was not seen.

ILLINOIS: ***Carroll Co.:** Wet grounds near entrance to Mississippi Palisades State Park, N of Savannah, *Wunderlin 2668* (MWI).

IOWA: ***Allamakee Co.:** Lansing Twp.: Lansing Wildlife Refuge, 2–3 ha marsh, T99N R4W S12, *Peck 78-54* (ISTC, KIRI, MICH), *Farrar 78-6-3-1* (ISC), *Roosa 1759* (ISTC). Banks of Mississippi River, June 1900, *Orr s. n.* (EMNM). ***Des Moines Co.:** Huron Twp.: Near pumping station No. 4, Iowa Slough, adjacent to Mississippi River, T72N R1W S4, *Lammers 1542* and *2087* (IA, ISC, ISTC), *Peck 78-300* (ISTC, KIRI, MICH).

MINNESOTA: ***Houston Co.:** Mississippi River flood plain in wetlands of Crooked Creek at Reno, *Peck 79-734* (KIRI, MICH, MIN, UWL). **Washington Co.:** Confluence of Valley Branch Creek and St. Croix River in thicket of *Salix interior, Swanson 2878* (MIN, UWL). ***Wabasha Co.:** Weaver Bottoms, floodplain of Mississippi River, 2 mi N of Weaver, *Peck 79-709* (KIRI, MICH, MIN, UWL). ***Winona Co.:** On floodplain of Mississippi River, W of Red Oak Island in Lake Onalaska, *Peck 79-727* (KIRI, MICH, MIN, UWL).

WISCONSIN: ***Buffalo Co.:** Nelson Twp.: Nelson-Trevino Bottoms of Mississippi River floodplain, T22N R14W S36, *Peck 79-824* (KIRI, MICH, WIS, UWL). ***Crawford Co.:** Emergent along shore near bridge over Swamp Creek, 0.5 mi E of Lynxville on County Road B, T9N R6W S23, 8 Jul 1973, *Dawson s. n.* (UWL). **Grant Co.:** Wilderness area of Wyalusing State Park, T6N R6W S20/21, 19 June 1959, *Patman s. n.* (WIS). **Green Lake Co.:** Marsh shore on S side of Lake Puckaway, Marquette, *Fassett 8799* (WIS). ***La Crosse Co.:** Barre Twp.: Seepage area at roadside ditch along Swamp Road,

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T16N R6W S20, *Peck 79-803* (KIRI, MICH, UWL, WIS). *__Pierce Co.__: Clifton Twp.: Marshy thicket at mouth of Kinnicinick River under *Salix interior*, T27N R20W, *Peck 79-824* (KIRI, MICH, UWL, WIS). Isabella Twp.: Marshy slough, backwater of Mississippi River. 0.5 mi W of Bay City, T24N R17W S7, *Peck 79-838* (KIRI, MICH, UWL, WIS). **Richland Co.:** Shallow water springhole in slough of Wisconsin River, 3 mi E of Gotham, T8N R2E S4, *Hartley 5266* (IA, WIS). *__Rock Co.__: Marsh and lowlands east of cooling canal on Rock River near Beloit, *Rice 1649* (UWJ, WIS). *Trempealeau Twp.: Marshy edge of backwater area of Mississippi River floodplain in Delta Fish and Fur Farm, T18N R10W S11, *Peck 79-814* (KIRI, MICH, UWL, WIS). *__Vernon Co.__: Genoa Twp.: Shore to Bad Axe River near Mississippi River, T12N R7W S12, *Peck 79-813* (KIRI, MICH, UWL, WIS). **Winnebago Co.:** Springy shore of Fox River near Eureka, *Fassett 13243* (WIS).

The habitat of the hybrid is a shallow marsh or slough adjacent to a watercourse which has a fluctuating water level, periodically flooding or stranding the site where the hybrid occurs. The hybrid occurs in stands ranging from 1 m^2 to 2–3 ha, with many stands 0.05–0.1 ha in extent. Species diversity within the stand is very low compared to adjacent marshes. The most common associates are *Sagittaria latifolia*, *Salix interior*, and *Typha latifolia*. The parent species were found at the periphery of the hybrid's stand, but rarely within the stand. The hybrid appears to be quite aggressive in a habitat which is subjected to repeated disturbance by flooding and sediment deposition.

TABLE 1. CHANGES IN *EQUISETUM* × *LITORALE* STAND HEIGHT AND DENSITY IN ALLAMAKEE COUNTY, IOWA, DURING 1979.

Sample Date	*Stand height* ($\bar{x}$ ± sd)	*Stand density* (stems/m^2)	*Survivorship* (% of 21 April)
21 April	0.05 ± 0.012	2809 ± 61.8	100
12 May	0.49 ± 0.049	2560 ± 82.9	91
12 June	1.03 ± 0.101	1792 ± 133	64
30 July	1.52 ± 0.082	1324 ± 148	47
20 Aug[1]	0	0	0
15 Sep[2]	0.34 ± 0.031	32 ± 11.4	1

[1]Stand lodged; all aerial parts senescent.
[2]Aerial stems newly arisen from subterranean stems.

Stand dynamics were monitored in 1979. A transect was established the length of the stand. Twenty-five 0.25 m^2 quadrats were selected at random points along the transect. Stand density was assessed by counting the number of stems per quadrat. Stand height was assessed by measuring the height of two corner plants per quadrat. Subsequent observations were made from a series of transects 5 m distant from and parallel to the previous transect. An average value for stand density (stems/m^2) and stem height was calculated for each transect. Survivorship of aerial stems through the growing season was calculated based upon the average stand density on April 21. Results are presented in *Table 1*. Stand density was greatest in spring and declined until summer, when only 47% of its initial stand density was present. Considering the initial stand density (2,809 stems/m^2), extensive self-thinning was expected. Stand height increased through time, resulting in mean stand height of 1.52 m, with some exceptionally tall specimens over 2 m.

The stand was flattened by a severe storm in early August 1979. Consequently, no measurements could be taken on August 20th. However, by September 15th, the stand had sprouted new aerial stems from subterranean stems. These new stems produced a comparatively sparse growth of limited stature. The new growth

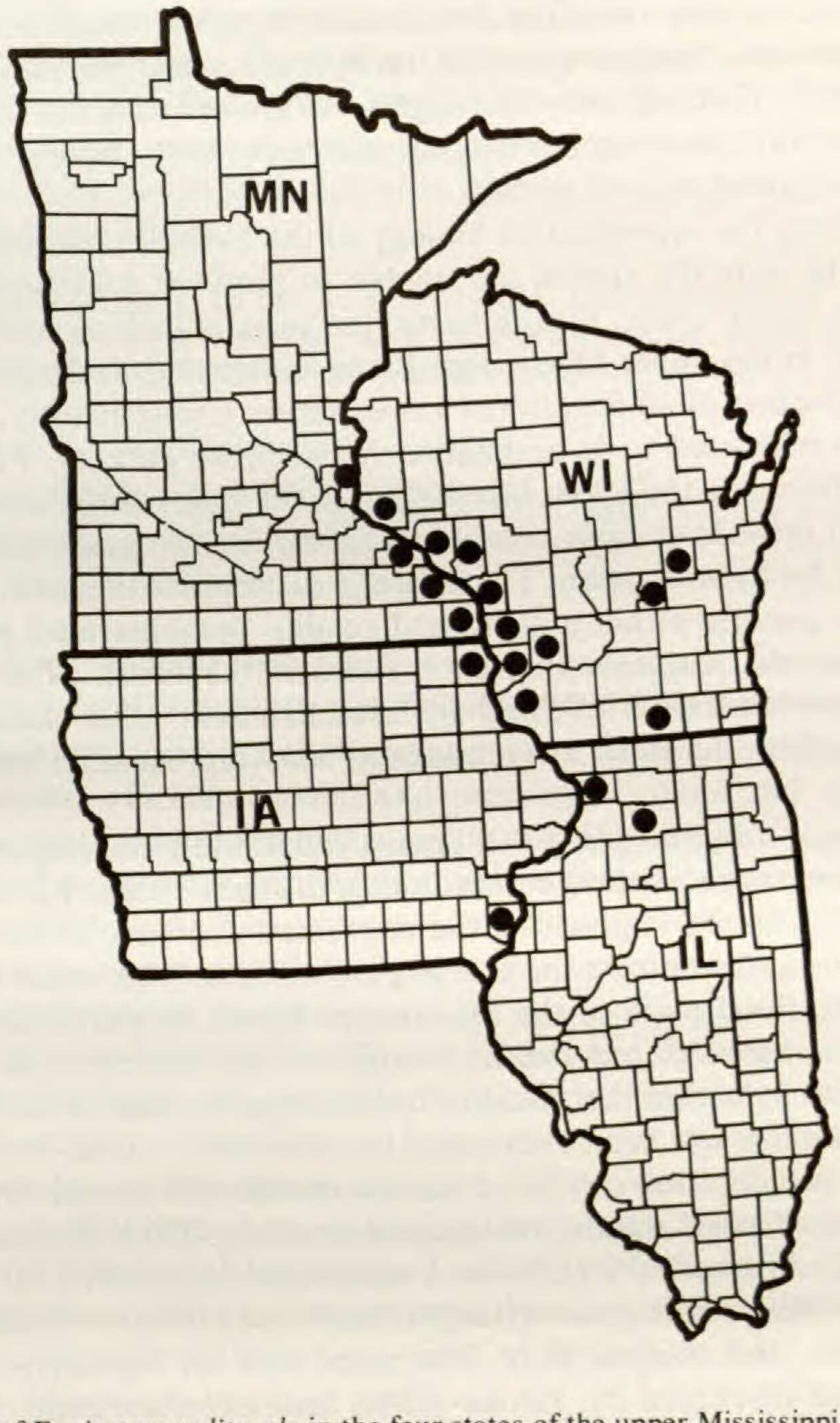

FIG. 1. Distribution of *Equisetum* × *litorale* in the four states of the upper Mississippi River Valley.

protruded through a 10–18 cm thick mat of senescent and decaying aerial stems that lodged following the storm. The stand also lodged in 1978 following a storm in July. The new growth that year attained a mean height of 1.2 m. The extent of recovery, therefore, is probably influenced by the time of lodging, with an earlier date favoring a stronger recovery.

Observations on stand dynamics were also made on an adjacent pure stand of the parent species. Those stands were less densely stocked and did not recover following lodging to the extent the hybrid did. Whereas the hybrid occurs with stands of low species diversity, the parent species exist with many more species present within their stands. The lack of colonization or establishment within the hybrid's stands and the extensive colonization in parent stands in autumn suggests that the thick mat of lodged stems in the hybrid's stand physically prevents successful invasion. Consequently, the aggressive growth of aerial stems and capability to recover from mid-summer lodging contribute to the hybrid's ability to maintain stands of low species diversity.

In considering the reproductive biology of the hybrid, it should be noted at the outset that the hybrid's spores are unable to produce gametophytes and, thus, complete the sexual cycle. Furthermore, the general lack of strobilus production by the hybrid in the upper Mississippi River valley essentially precludes the rare event of production of an occasional viable spore. Consequently, sexual origin of the hybrid is restricted to hybridization between its parents. Frequent flooding along watercourses in the upper Mississippi River valley forms extensive sand and mud flats that provide suitable conditions for *Equisetum* gametophytes and ample opportunities for hybridization. The hybrid's occurrence in small, discrete stands, with uniform growth within a stand and readily demonstrated physical connections underground, suggests that each stand is the result of a single or a few successful hybridizations followed by establishment of a clone by vegetative growth. Therefore, the stand at each locality may represent an independent origin of the hybrid.

Once formed, a hybrid plant can persist indefinitely as long as it avoids catastrophic factors, such as desiccation during drought years. An indication of the longevity of the hybird is given by the continued presence of the hybrid in Allamakee Co., Iowa, for at least the last 80 years. Since 1900, when Ellison Orr first noted it on the flood plain of the Mississippi River, establishment of navigation lock and dams has changed the hydrology of the shoreline environment. The presence of the hybrid in that locality today suggests that its historical presence and persistence has not been eliminated by alterations to the shoreline.

Vegetative proliferation of hybrid stands, on the other hand, was suggested by the occurrence of small stands and isolated stems 50–350 m downstream from the 2–3 ha stand in Allamakee Co., Iowa. Fragmentation followed by water dispersal of stems and their subsequent establishment downstream would result in new stands from the same original plant. The propensity for vegetative proliferation of *Equisetum* was discussed by Hauke (1963) and experimentally investigated by Wagner & Hammitt (1970). In early August 1979, an experiment was conducted to verify the hybrid's ability to undergo vegetative proliferation and to contrast this ability with that of its parents. Aerial stems and subterranean stems of the hybrid and its parents were cut and either placed on mud or buried in the mud flat. Twenty-five stems were used per pecies per treatment. The plots were inspected in early September. The results (*Table 2*) indicate that burial increased the chance that a fragment would form a new plant, that subterranean parts withstood the

stress of fragmentation, dispersal, and establishment better than aerial stems, and that the hybrid's ability is equal to or superior to that of its parents.

In summary, the origin, maintenance, and dispersal of the hybrid is favored by the physical results of flooding. Flooding can form mud flats where sexual formation of the hybrid can occur, lodge aerial stems into a mat that prevents invasion of the hybrid's stands by potential colonizers, and facilitate vegetative proliferation by physically breaking stems, dispersing them downstream and leaving them stranded or buried on mud flats where new stands can become established. Although vegetative proliferation probably has expanded the hybrid within its locality, evidence of long distance dispersal is lacking, in that both parents occur with the hybrid in these states.

TABLE 2. COMPARATIVE ABILITY OF *E.* × *LITORALE* AND ITS PARENT SPECIES TO REGENERATE PLANTS FROM AERIAL AND SUBTERRANEAN STEM FRAGMENTS AFTER BEING LODGED ON OR BURIED IN A MUD FLAT.

Species	*Cut and Lodged*		*Cut and Buried*	
	Aerial	*Subterranean*	*Aerial*	*Subterranean*
E. arvense	0%	20%	60%	68%
E. × *litorale*	0%	16%	40%	96%
E. fluviatile	0%	8%	0%	20%

These observations suggest that analysis and integration of habitat, stand dynamics, and reproductive ecology are feasible with *Equisetum,* and possibly with other pteridophytes. Additional observations are needed on changes in nutritional status (calories, macronutrients, and protein) of aerial and subterranean stems through the year. Additional measures on stand dynamics (height, density, biomass) are needed to contrast peripheral stands reported on here with stands to the north and east. Competitive experiments between the hybrid, parent species, and flowering plant associates would improve our understanding of *Equisetum* ecology.

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REVIEW

"FLORA DE LA PROVINCIA DE JUJUY REPUBLICA ARGENTINA, PARTE II. PTERIDOPHYTA," by E. R. de la Sota. Angel L. Cabrera, general editor. Instituto Nacional de Tecnología Agropecuária, Buenos Aires, Argentina, 1977. Ps. 22,000 (ca. $28.00).—INTA is publishing a series of very attractive Flora volumes for the provinces of Entre Rios and Jujuy (both in northern Argentina) and for the Patagonian region. This volume is the first on ferns for the three series. The endpapers have useful physiographic, phytogeographic, and political maps of the province. The book begins with a few pages concerning the morphology, cytology, reproduction, and systematics of the Pteridophyta. General keys lead to 23 families, which are used in a modern sense similar to that in Jermy and Mickel's classification. Each species treatment includes a synonymy, description, notes, and list of specimens. Each is illustrated with a nicely drawn habit sketch plus sketches of morphological details. Some 244 taxa are treated, judging by the index that concludes the volume. The printing is mostly of high quality, although a few plates had some light areas across them and a few typographical errors can be found. The weakest point of the book is the binding. This book will be highly useful to all who need to know the pteridophytes of northwestern Argentina and vicinity. Orders should be sent to INTA Publicaciones, Chile 460, 1098 Buenos Aires, Argentina.—*D.B.L.*